



A European Disease?Non-tradable inflation and real interest rate divergence

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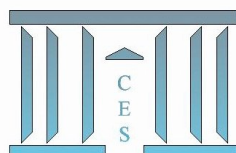
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A European Disease?
Non-tradable inflation and real interest rate divergence

Sophie PITON

2016.44



A European Disease?

Non-tradable inflation and real interest rate divergence

Sophie Piton*

Abstract: This paper studies the contribution of real interest rate divergence to the dynamics of the relative price of non-tradables within Europe. Based on a model by De Gregorio et al. (1994), it shows that the real interest rate fall in the Euro Area (EA) periphery following the single currency's inception induced an increase in the relative price of non-tradable goods. Using a new dataset, it documents the dynamics of the tradable and the non-tradable sectors over 1995-2013 and the expansion of the non-tradable sector in the periphery before the euro crisis. It then carries out an econometric estimation for 11 EA countries over 1995-2013 and quantifies the contribution of the pure Balassa-Samuelson effect and the impact of the interest rate on non-tradable relative prices. Diverging evolution in the interest rate impacted greatly the evolution of non-tradable relative prices within the euro area over the period. In Greece, the fall in the real interest rate over 1995-2008 could explain almost half of the non-tradable price increase relative to the EA average, while in Germany the increase in the real interest rate might have contributed up to 7% of the decrease of the non-tradable price relative to the average of the EA.

Keywords: Non-tradable prices; Balassa-Samuelson effect; Real interest rate.

Résumé : Cet article étudie dans quelle mesure la divergence des taux d'intérêt réels a contribué à la dynamique du prix des biens non échangeables en zone euro. Partant d'un modèle proposé par De Gregorio et al. (1994), il montre que la baisse du taux d'intérêt réel dans les pays périphériques de la zone euro (ZE) après l'adoption de la monnaie unique a induit une augmentation du prix relatif des biens non échangeables. L'utilisation d'une nouvelle base de données permet de documenter la dynamique des secteurs abrités et ouverts sur la période 1995-2013 et de montrer l'expansion du secteur abrité dans les pays périphériques avant la crise de l'euro. Une estimation économétrique est menée pour 11 pays de la ZE sur la période 1995-2013 pour quantifier la contribution de l'effet Balassa-Samuelson et l'impact du taux d'intérêt sur les prix relatifs des biens non échangeables. Il semble que la divergence dans l'évolution des taux d'intérêt a fortement impacté l'évolution des prix des biens non échangeables dans la zone euro sur la période. En Grèce, la baisse du taux d'intérêt réel sur la période 1995-2008 pourrait expliquer près de la moitié de l'augmentation des prix des biens non échangeables par rapport à la moyenne de la ZE, alors qu'en Allemagne, l'augmentation du taux d'intérêt réel pourrait expliquer 7 % de la diminution du prix des biens non échangeables par rapport à la moyenne de la ZE.

Mots-clés : Secteur abrité; effet Balassa-Samuelson; taux d'intérêt réel.

JEL: F41; F45; E43.

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1. Introduction

When the euro was introduced, conditions for economic convergence –the process of narrowing income gaps between lower and higher income countries– seemed to be present.¹ Nominal interest rates between higher and lower income countries had converged rapidly² and capital was flowing from the richer (the "core") to the poorer (the "periphery") countries of the area. This convergence process was supposed to be the main reason behind the strong macroeconomic divergence between the core and the periphery, and the imbalances were supposed to be reduced as countries would converge. The 2010 euro crisis has challenged this view, with macroeconomic divergence among countries pointed to as reflecting bad imbalances. In particular, debates have emerged to reassess the mechanisms behind the divergence in inflation rates across countries and behind substantial price differentials between tradable and non-tradable goods in some countries. Even though there is evidence of a convergence of tradable prices across Europe and higher productivity growth in the tradable sectors of catching-up economies, there seems to be a growing consensus that the Balassa-Samuelson (BS) effect³ cannot be the sole explanation to the steep rise in the non-tradable relative to the tradable price in the Euro Area (EA) periphery before the crisis (Estrada et al., 2013).

This paper further investigates the mechanisms behind the divergence of relative (non-tradable to tradable) prices across Europe. The starting point is Figure 1 which shows the evolution of relative prices and real interest rates in the periphery compared to core countries over 1995-2013. The periphery, facing a steep increase in relative prices, also faced a strong decrease in real interest rates up to 2008. Introducing two factors of production in the BS framework, the paper shows that the real interest rate fall in the EA periphery following the single currency's inception induced an increase in the relative price of non-tradable goods. Using a new dataset, it then documents the dynamics of the tradable relative to the non-tradable sector over 1995-2013 and highlights the expansion of the non-tradable sector in the periphery before the euro crisis. Finally, it carries out an econometric estimation for 11 EA countries over 1995-2013 to quantify the contribution of the pure BS effect and that of the interest rate reduction on non-tradable relative prices.

A growing literature has analyzed the impact of falling interest rates on the increase in relative prices of non-tradables. In 1983 already, Dornbusch (1983) showed how an exogenous disturbance in the real interest rate can affect the price of non-traded goods by fueling a demand boom. This argument has also been suggested more recently by Fagan and Gaspar (2007). Other papers analyze the impact of the interest rate on the supply side rather than on the demand-side of the economy: Reis (2013), studying the case of Portugal, suggests that capital inflows were misallocated within the non-tradable sector due to financial frictions, fueling transitory price increases in this sector. Other authors look at the impact of such misallocation on the sustainability of the current account and the probability of a balance of payment crisis (Giavazzi and Spaventa, 2011; Kalantzis, 2015).

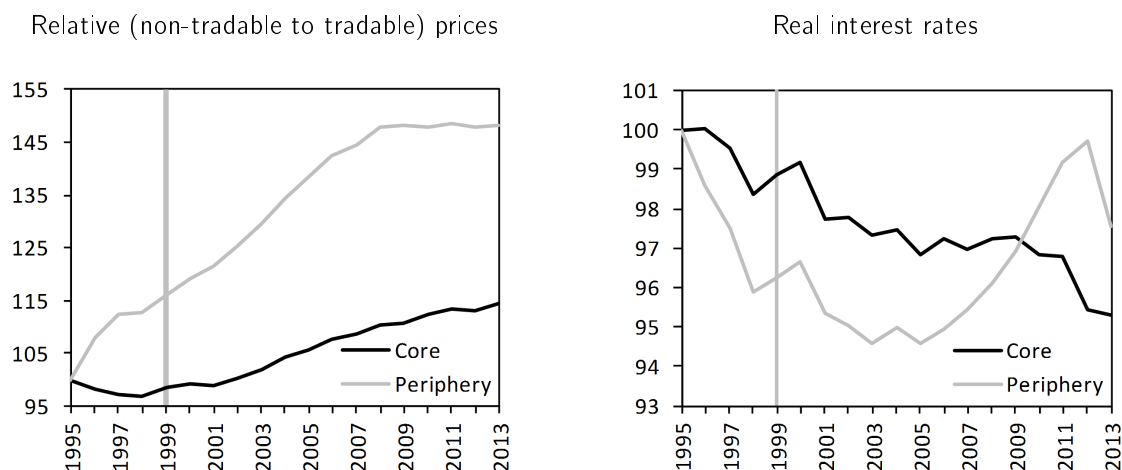
This paper departs from these analyses in the way that it studies the impact of interest rate variations in a BS framework. The BS framework has already been subject to various extensions

¹Blanchard and Giavazzi (2002) suggested that current account deficits in the periphery after the euro's inception reflected mainly a catch-up and convergence process.

²The periphery faced, on average between 2001-2008, a real rate of 0.26% against 1.4% for the rest of the euro area as a whole (Ameco, February 2016.)

³Balassa (1964) and Samuelson (1964) suggested that higher inflation rates in catching-up economies could reflect a process of real convergence: assuming the law of one price holds for tradable goods, productivity growth in this sector pushes real wages up both in the tradable sector and the non-tradable one; it results in an increase in the relative price of non-tradable goods and thus in a real exchange rate appreciation in catching-up economies.

Figure 1 – Relative prices and real interest rates in the periphery vs. core countries, 1995-2013
indices 1995=100



Source: author's calculations using Eurostat, BACI and UN ServiceTrade and Ameco.

Note: relative prices are measured using the 10% threshold for tradability and are the ratio of non-tradable prices relative to the tradable price of the EA11. Variables for each group are weighted averages (weight: gross value added at current prices). The real interest rate is deflated by GDP deflators. The periphery includes: Spain, Portugal, Italy, Ireland, Greece. Core countries are: Austria, Belgium, Germany, Finland, France, Netherlands. The grey vertical lines indicate the euro introduction (1999).

to explain the permanent drift in non-tradable prices. Among others, [De Gregorio et al. \(1994\)](#) suggest that it could be explained by an exogenous demand-shift towards non-tradable goods. More recently [Bénassy-Quéré and Coulibaly \(2014\)](#) suggest that inflation differentials in Europe also originate in heterogeneous market regulations. This paper shows that in the long term, a permanent and exogenous decrease in the interest rate will lead to a permanent drift in non-tradable prices as long as the non-tradable sector is labor-intensive. This is, to our knowledge, the first attempt to analyze the impact of the interest rate in a BS framework.

The remainder of the paper is organized as follows. Section 2 extends the usual BS theoretical framework to analyze the impact of a fall in the real interest rate on the non-tradable relative price. Section 3 describes the dataset and the construction of a tradability indicator, and then documents the dynamics of the non-tradable and tradable sectors over 1995-2013 in 11 countries of the EA. Section 4 presents the econometric strategy, reports empirical estimation results and robustness tests. Section 5 concludes.

2. Conceptual framework

The workhorse model to analyze the evolution of non-tradable prices in an open economy is the framework set by [Balassa \(1964\)](#) and by [Samuelson \(1964\)](#). Their model features a small open economy with a perfectly competitive tradable sector (the price being determined by the world market), and a non-tradable sector (the price being determined domestically). Labor is the only factor of production. They show that, assuming the law of one price holds for tradable goods,

productivity growth in this sector pushes real wages up both in the tradable sector and in the non-tradable one. This results in an increase in the relative price of non-tradable goods and thus in a real-exchange rate appreciation, which is commonly known as the BS effect. Several theoretical extensions have been proposed in the literature.⁴ Some of them consider two factors of production (labor and capital), or examine the implications of incorporating a demand-side in the BS framework (see, among others, [De Gregorio et al., 1994](#); [Obstfeld and Rogoff, 1996](#); [Bénassy-Quéré and Coulibaly, 2014](#)).⁵ This paper is the first attempt to look at the impact of an exogenous change in the interest rate on the evolution of the non-tradable relative price. It focuses on the supply-side and builds on the framework set by [De Gregorio et al. \(1994\)](#) to show the impact of both faster productivity growth in the tradable sector and an exogenous and permanent fall in the interest rate on the relative price of non-tradable goods.

The model features a small open economy with two goods: a tradable, the numeraire, whose market is perfectly competitive and subject to the law of one price; a non-tradable good, which price is set domestically. Production takes place using two inputs: capital (mobile internationally and between sectors) and labor (mobile between sectors but not internationally). Labor sectoral mobility ensures that workers earn the same wage in either sector whereas capital international mobility ensures that the interest rate is given internationally.

Representative firms in each sector face a Cobb Douglas production function with two factors of production, of the form:

$$Y_T = A_T K_T^{\alpha_T} L_T^{1-\alpha_T} \quad (1)$$

$$Y_N = A_N K_N^{\alpha_N} L_N^{1-\alpha_N} \quad (2)$$

where the subscripts T and N denote the tradable and non-tradable goods, Y denotes real output, L labor inputs and K capital. α_T, α_N represent capital intensity in each sector ($\alpha_T, \alpha_N \in]0, 1[$). Given that the tradable good acts as a numeraire, and given that the interest rate r is exogenous, combining first order conditions in the tradable sector yields the equation for the real wage (nominal wage deflated by the numeraire T), ω :

$$\omega = r^{-\frac{\alpha_T}{1-\alpha_T}} A_T^{\frac{1}{1-\alpha_T}} \alpha_T^{\frac{\alpha_T}{1-\alpha_T}} (1 - \alpha_T) \quad (3)$$

Combining first order conditions in the non-tradable sector, given r and ω , yields the equation for the non-tradable relative price p :

$$p = \frac{1}{A_N} \left(\frac{\omega}{1 - \alpha_N} \right)^{(1-\alpha_N)} \left(\frac{r}{\alpha_N} \right)^{\alpha_N} \quad (4)$$

Plugging (3) into (4), we get that the non-tradable relative price is determined entirely by technological conditions and is independent of demand conditions. The relative price depends on the rate of interest (r) and on the tradable and non-tradable sector productivities (A_T, A_N) and capital intensities (α_T, α_N):

$$p = r^{\frac{\alpha_N - \alpha_T}{1-\alpha_T}} \frac{[A_T (1 - \alpha_T)^{1-\alpha_T} \alpha_T^{\alpha_T}]^{\frac{1-\alpha_N}{1-\alpha_T}}}{A_N (1 - \alpha_N)^{1-\alpha_N} \alpha_N^{\alpha_N}} \quad (5)$$

⁴See [Bahmani-Oskooee and Nasir \(2005\)](#) for a review.

⁵In all cases, demand shocks appear unable to move the real exchange rate in the long run.

The BS effect postulating a positive link between faster productivity growth in the tradable sector and the relative price of the non-tradable good is straightforward. Other things constant, a rise in the productivity of the tradable sector (A_T) decreases the price of this sector relative the non-tradable one. This BS effect goes through the impact of A_T on ω :

$$\frac{d\omega}{dA_T} = \frac{1}{1 - \alpha_T} A_T^{\frac{\alpha_T}{1-\alpha_T}} r^{-\frac{\alpha_T}{1-\alpha_T}} \alpha_T^{\frac{\alpha_T}{1-\alpha_T}} (1 - \alpha_T) > 0$$

This wage increase ensures that the marginal cost of tradables remains constant but it increases the marginal cost, and hence the relative price, of the non-tradable good:

$$\frac{dp}{dA_T} = \frac{1 - \alpha_N}{1 - \alpha_T} A_T^{\frac{\alpha_T - \alpha_N}{1-\alpha_T}} r^{\frac{\alpha_N - \alpha_T}{1-\alpha_T}} \frac{1}{A_N} \left(\frac{1 - \alpha_T}{1 - \alpha_N} \right)^{1-\alpha_N} \alpha_T^{\frac{\alpha_T(1-\alpha_N)}{1-\alpha_T}} \alpha_N^{-\alpha_N} > 0$$

In turn, the impact of an exogenous and permanent fall in the interest rate on the relative non-tradable price depends on the capital intensity of the non-tradable relatively to the tradable sector ($\alpha_N - \alpha_T$). Indeed, a fall in the interest rate –all other variables remaining constant– is matched by a wage increase ensuring that the marginal cost of tradables remains constant:

$$\frac{d\omega}{dr} = -\frac{\alpha_T}{1 - \alpha_T} r^{\frac{-1}{1-\alpha_T}} A_T^{\frac{1}{1-\alpha_T}} \alpha_T^{\frac{\alpha_T}{1-\alpha_T}} (1 - \alpha_T) < 0$$

If the non-tradable sector is relatively more (less) labor intensive, this rise in wages will increase (decrease) the marginal cost, and hence the relative price, of the non-tradable good:

$$\frac{dp}{dr} = \frac{\alpha_N - \alpha_T}{1 - \alpha_T} r^{\frac{-1-\alpha_N}{1-\alpha_T}} A_T^{\frac{1-\alpha_N}{1-\alpha_T}} \frac{1}{A_N} \left(\frac{1 - \alpha_T}{1 - \alpha_N} \right)^{1-\alpha_N} \alpha_T^{\frac{\alpha_T(1-\alpha_N)}{1-\alpha_T}} \alpha_N^{-\alpha_N} < 0 \quad \text{if } \alpha_N < \alpha_T$$

Expressing all variables relative to the Euro area (EA) average, assuming the law of one price holds in the tradable sector ($p_T = p_T^{EA}$), and assuming, as in the literature, that productivity grows faster in the tradable sector than in the non-tradable sector, the empirically testable model is given by:

$$\left(\frac{p_N}{p_N^{EA}} \right) = f \left(\left(\frac{A_T}{A_T^{EA}} \right), \left(\frac{r}{r^{EA}} \right) \right) \quad (6)$$

where A_T stands for productivity in the tradable sector, r the real interest rate, and EA subscripts stand for euro area averages. For similar productivity growth in the non-tradable sector, the country should experience a relative increase in its non-tradable price if its productivity growth in the tradable sector is stronger than the average productivity growth of the T sector in the euro area: we expect a positive coefficient on the first variable. Similarly, the country is expected to experience a non-tradable price increase if its real interest rate (expressed in terms of tradables) decreases more than it does, on average, in the EA, given that the non-tradable sector is more labor intensive than the tradable one. There seems to be evidence supporting this assumption that the non-tradable sector is more labor-intensive than the tradable sector. [van Riet and Roma \(2006\)](#) show that services sectors are less capital intensive than the manufacturing sectors in the euro area at the beginning of the 2000s. Moreover, they show that Southern European countries tend to be characterized by a smaller average firm size than the Euro area aggregate, and have a larger share of self-employment in the service sector, making this sector even more labor intensive than in the rest of the EA. This assumption is also confirmed in the dataset used here. These results will be tested empirically after describing the dataset used and documenting patterns in the non-tradable sector inflation across Europe over 1995-2013.

3. Data

3.1. Data sources

Most studies label the manufacturing sector as tradable and consider services sectors as non-tradable. However, services represent an increasing share of advanced economies' exports. To reassess the tradability of both goods and services, one needs to construct a database allowing to compare trade in goods and services, and national accounts data at a sectoral level. Eurostat provides data for national accounts for up to 64 sectors in the NACE revision 2 classification. It provides detailed information on Gross Value Added (GVA) in current and constant prices, production at current and constant prices, employment and labor compensation for European countries. For data on trade in goods, BACI, CEPII's database based on COMTRADE, provides a harmonized world trade matrix for values at the 6-digit level of the Harmonized System of 1992. Data are available from 1989 to 2013 for 253 countries and 5 699 products. Finally, for trade in services, UN ServiceTrade database provides data on services exports and imports in the BPM5 classification over 2000-2013.

All databases are converted into a 21-level NACE revision 2 classification, to get an unbalanced database⁶ providing data on gross value added at current and constant prices, production at current and constant prices, labor compensation at current prices, employment and the value of trade in goods and services and goods export for up to 11 EA countries (EA11)⁷ over 1995-2013. It is then possible to measure gross value added deflators (chained linked indices, using 1995 as the reference year) and labor apparent productivity (value added in volume per hour worked) as a proxy for total factor productivity. Finally, series on annual real⁸ long-term interest rates come from Ameco.

3.2. Defining tradability

The tradability of a good or a service sector is defined as the capacity to trade its output internationally. As in [De Gregorio et al. \(1994\)](#) and most of the empirical literature, the extent to which a good or a service is actually traded with a foreign country is used as a proxy for its tradability. Therefore, the tradability of each sector at the euro area (EA11) level depends on its openness ratio –the ratio of total trade (imports + exports) of the EA11 to total production in the EA11. As in [De Gregorio et al. \(1994\)](#) we use a threshold of 10%, so a sector is considered as being tradable if the average of its openness ratio over 2000-2013 is higher than 10% (the openness ratio for the period 1995-1999 cannot be measured since data on trade in services are not available for this period).

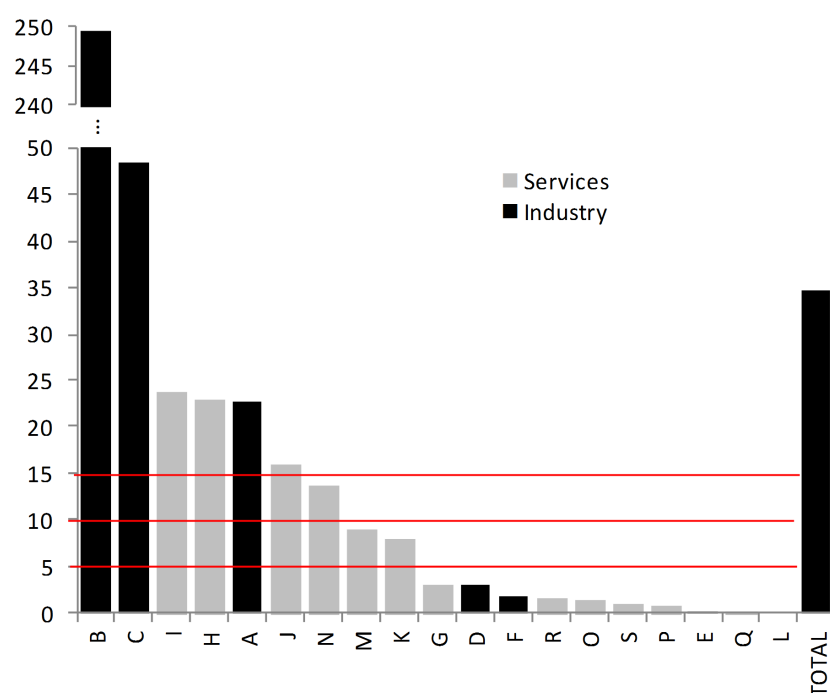
Figure 2 reports the openness ratio by sector on average over 2000-2013 (see Table A.1 in Appendix for more details). Unsurprisingly, agriculture, the manufacturing and mining and quarrying sectors are in the tradable sector. Concerning services, four industries are considered as tradable: accommodation and food service activities; transportation and storage; information and communication, and administrative and support service activities. The tradable sector accounts for 47% of total production, 36% of GVA (both at current prices) and 39% of employment.

⁶Information on disaggregated trade in services is available only for the period 2000-2013.

⁷The 11 EA countries are: AT: Austria; BE: Belgium; DE: Germany; EL: Greece; ES: Spain; FI: Finland; FR: France; IE: Ireland; IT: Italy; NL: Netherlands; PT: Portugal.

⁸Long-term interest rate deflated by GDP deflators.

Figure 2 – Openness ratio and tradability by sector, EA11
Average 2000-2013, in %



Source: author's calculations using Eurostat, BACI and UN ServiceTrade.

Note: the red lines indicate the 15%, 10% and 5% thresholds.

A: Agriculture, forestry and fishing; B: Mining and quarrying; C: Manufacturing; D: Electricity, gas, steam and air conditioning supply; E: Water supply; sewerage, waste management and remediation activities; F: Construction; G: Wholesale and retail trade; repair of motor vehicles and motorcycles; H: Transportation and storage; I: Accommodation and food service activities; J: Information and communication; K: Financial and insurance activities; L: Real estate activities; M: Professional, scientific and technical activities; N: Administrative and support service activities; O: Public administration and defense; compulsory social security; P: Education; Q: Human health and social work activities; R: Arts, entertainment and recreation; S: Other service activities.

Inevitably, the threshold of 10% is arbitrary. One possibility could be to apply different tradability criteria for different countries, but applying the same criterion for all countries leads to more clearcut results.⁹ Using a threshold of 15% would exclude administrative and support service activities from the tradable sector. The tradable sector would then account for 43% of total production and 32% of GVA (at current prices), and 33% of employment. Using a threshold of 5% would include 2 other sectors in the tradable sector, and more particularly financial and insurance activities. The tradable sector would then account for 57% of total production and 47% of GVA (at current prices), and 47% of employment.

However, for financial and insurance activities for example, recent empirical work (Jensen and Kletzer, 2005; Gervais and Jensen, 2013) shows that financial and insurance activities are heterogeneous

⁹At country-level, tradability could be affected by market regulations or market structure, which should not matter for the EA11 since tradable sectors are well integrated in Europe (Estrada et al., 2013).

and contain both tradable and non-tradable activities.¹⁰ Therefore, labeling this sector as tradable or non-tradable is not straightforward. A few authors show the deep linkages between the non-tradable sector expansion and the banking and financial activity (see, for example, [Sy, 2016](#)), supporting the assumption of considering financial and insurance activities as non-tradable. As the choice of a 10% threshold is arbitrary, the 15% and 5% thresholds will be used to check the robustness of the empirical results.

3.3. Stylized facts: the drift from the tradable to the non-tradable sector

Figure 3 describes the evolution of gross value added, employment and prices in the non-tradable sector relative to the tradable sector, for each country of the EA11, for two subperiods: 1995-2008 and 2008-2013.¹¹ The 10% threshold is used to classify each sector as tradable or not, but similar figures using other thresholds are reported in Appendix. Relative prices are measured as the ratio of non-tradable to the tradable price in the EA11.¹²

Figures 4 and 5 report the contribution of each sector to the average price and employment growth over the two sub-periods: 1995-2008 and 2008-2013. Contributions to price growth are measured as the average inflation over the period in the considered sector weighted by its share in total GVA in volume at the initial year (1995 or 2008). Contributions to employment growth are measured as the average employment growth in the considered sector weighted by its share in total employment in thousands of hours at the initial year (1995 or 2008).

Figure 3, for the first sub-period (1995-2008), highlights the similar pattern in all peripheral countries: the hypertrophy of the non-tradable sector. This pattern is also striking when using other thresholds for the measurement of tradability. Prices in the non-tradable sector relative to the tradable sector rose sharply between 1995 and 2008 in Ireland, Italy, Portugal, Spain and Greece. The rise in relative prices and the growing share of the non-tradable sector led to a strong rise in overall prices and wages. However, some differences remain among the peripheral countries.

As [Giavazzi and Spaventa \(2011\)](#) have noted already, relative employment in Greece rose faster than relative GVA at current prices. The country faced a relatively smaller bubble in the housing sector (F-L) than Spain, with the housing sector contributing to 6p.p. of the average inflation over 1995-2008 (Figure 4). The main contributor to inflation and employment growth over 1995-2008 was the public, education and health sector (O_Q), contributing to respectively 4p.p. of the average employment growth (Figure 5) and 9p.p. of the average GVA deflator growth.

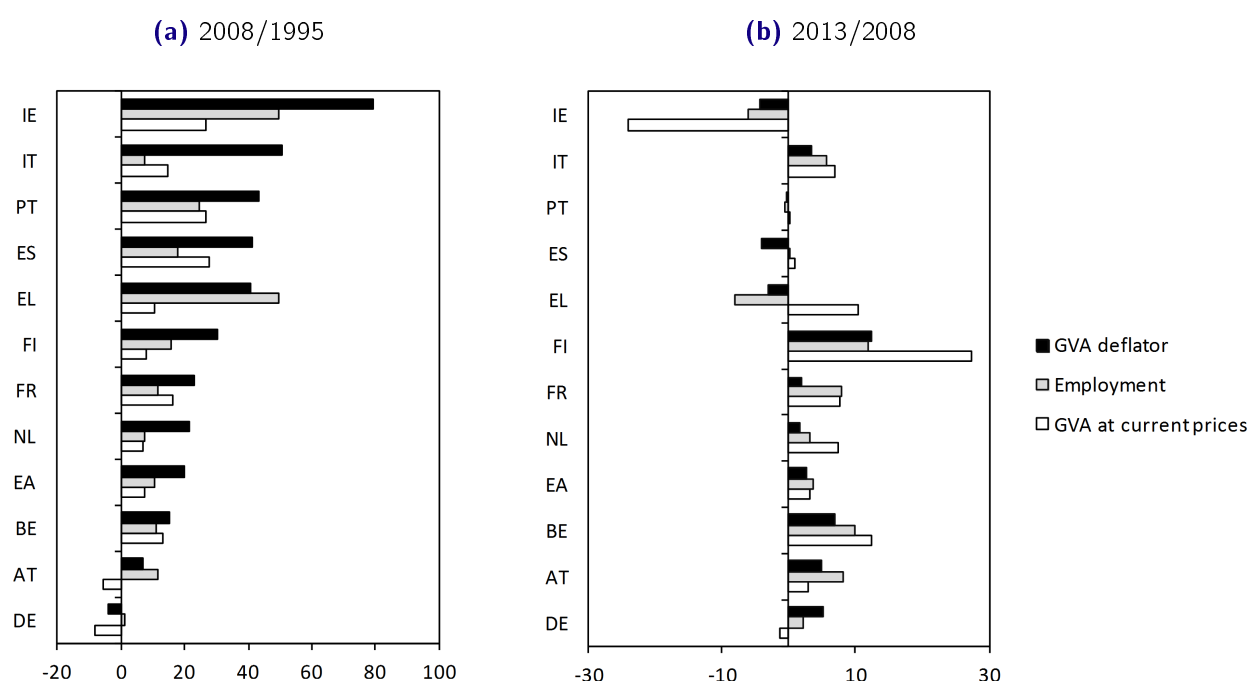
In Portugal, the non-tradable price increase was also led by both the housing and the public, education and health sectors, contributing respectively to 8p.p. and 9p.p. of the average inflation and 1p.p. and 3p.p. of average employment growth over 1995-2008. Employment decreased on

¹⁰These authors use the geographic concentration of activity as a proxy for the tradability of the industry. The more concentrated the activity, the higher its tradability. Applying this methodology on data on U.S. establishments, [Gervais and Jensen](#) show that the financial and business services sector has industries in both the top 5 most concentrated and least concentrated manufacturing and business services industries.

¹¹As seen on Figure 1, the trends of relative prices and real interest rates started to reverse after the 2008-crisis. We thus use the year 2008 as a break point for the stylized facts presented in this section.

¹²Like in the model and the following empirical analysis, the law of one price is assumed to hold in the tradable sector of the EA and the same tradable EA price is used as the numeraire for the 11 countries. The database used does not inform on price levels, but recent work show empirical evidence of a substantial convergence in price levels in the case of tradable goods (see [Estrada et al., 2013](#)). As the main focus of the paper is on the dynamics of the non-tradable sector, we assume the LOP holds and exclude from the analysis the dynamics specific to the tradable sectors.

Figure 3 – Evolution of the non-tradable relative to the tradable sector, %



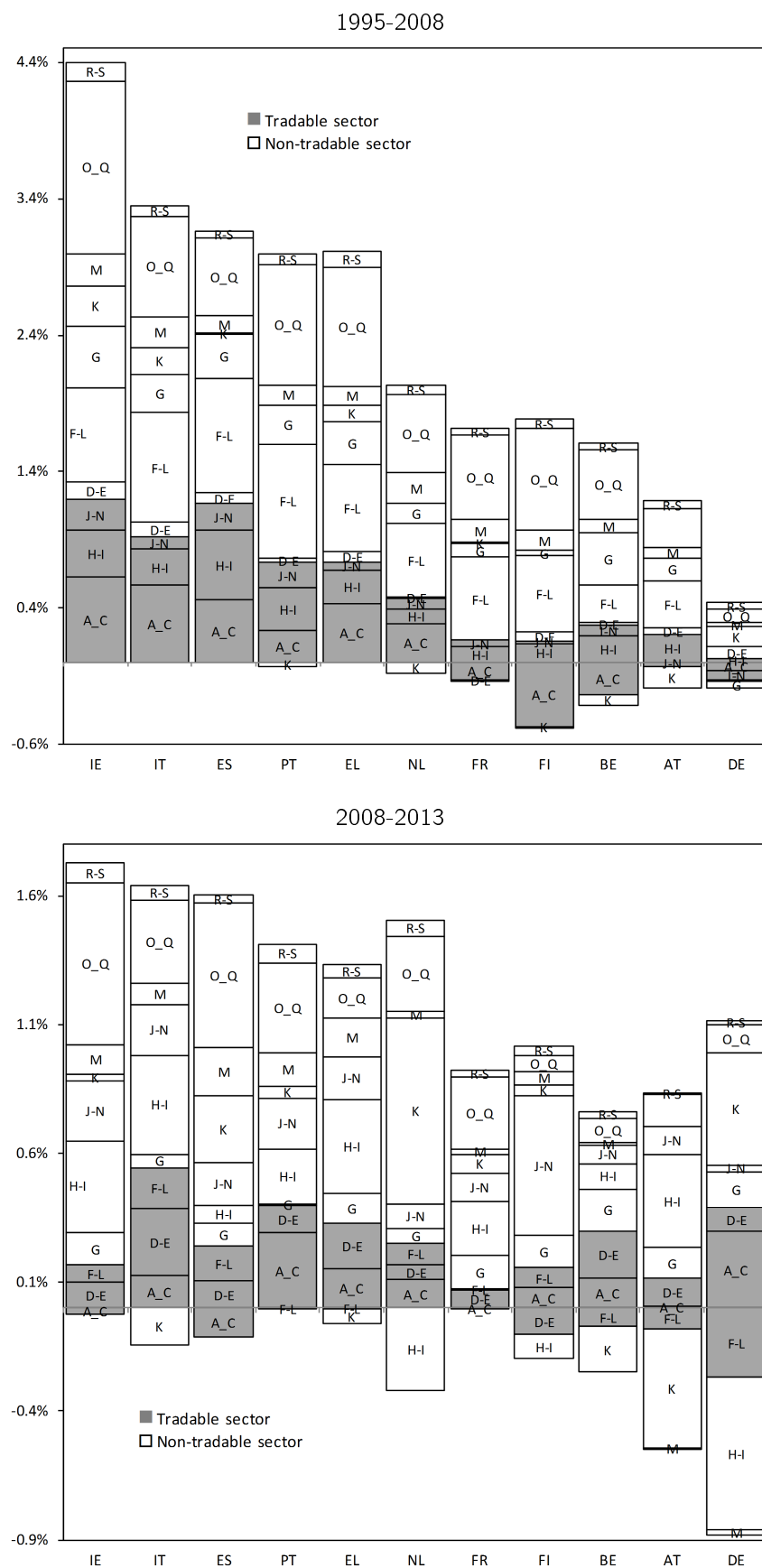
Source: author's calculations using Eurostat, BACI and UN ServiceTrade.

Note: relative prices are measured using the 10% threshold for tradability and are the ratio of non-tradable prices relative to the tradable price of the EA11. Employment is measured in thousands of hours worked.

average in the tradable sector –and especially for the industrial and agricultural activities (A_C) which had a negative contribution of -6p.p. to total employment growth.

Ireland and Spain were the two countries with the fastest employment growth over 1995-2008, both experiencing a housing bubble: the housing sector contribution to the average growth employment over the period reached 5p.p. and 6p.p. respectively. In Ireland, employment growth was also led by the expansion of the public, education and health sector. In Spain, the housing sector also contributed to a 8p.p. increase in the average inflation, and was by far the main contributor to price growth over 1995-2008.

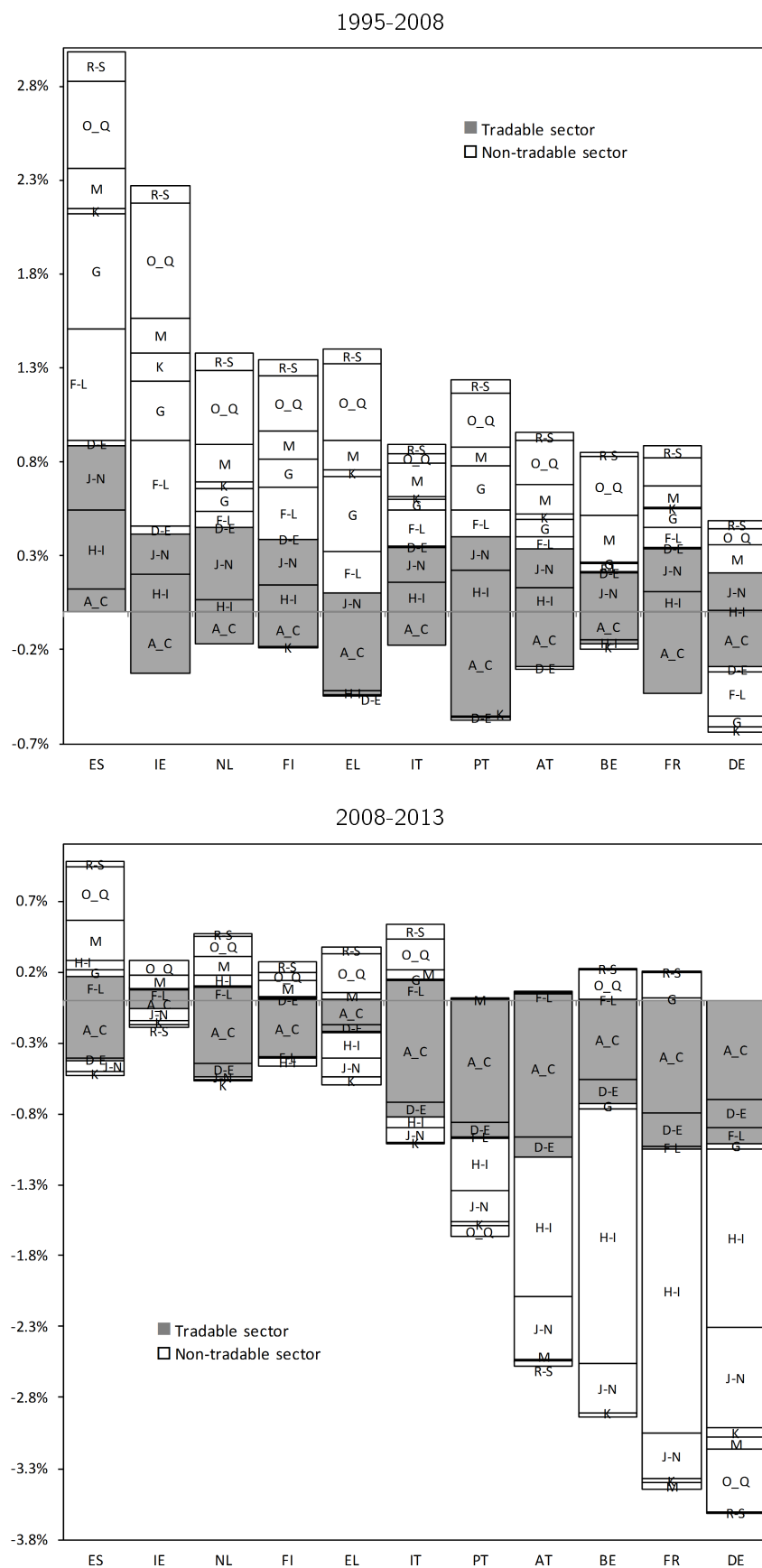
Figure 4 – GVA deflators: contributions of each sector to average growth over 1995-2008 and 2008-2013, by country



Source: author's calculations using Eurostat, BACI, UN ServiceTrade. Note: chained-linked indices, reference year: 1995. For the measurement of the tradability of each sector, the 10% threshold is used.

A_C: tradable industry; H-I: transportation, accommodation & food service activities; J-N: other tradable service activities; D-E: non-tradable industry; F-L: construction & real estate; G: wholesale and retail trade; K: finance & insurance services; M: other non-tradable business services; O_Q: public administration, education, health and social work activities; R-S: other non-tradable services.

Figure 5 – Employment: contributions of each sector to average growth over 1995-2008 and 2008-2013, by country



Source: author's calculations using Eurostat, BACI, UN ServiceTrade. Note: thousands of hours worked. For the measurement of the tradability of each sector, the 10% threshold is used.

A_C: tradable industry; H-I: transportation, accommodation & food service activities; J-N: other tradable service activities; D-E: non-tradable industry; F-L: construction & real estate; G: wholesale and retail trade; K: finance & insurance services; M: other non-tradable business services; O_Q: public administration, education, health and social work activities; R-S: other non-tradable services.

The evolution of the relative price of non-tradables seems to be well correlated to current account deficits: countries facing the steepest increase in prices have the largest deficits over 1995-2008. Since capital inflows did not serve to expand the tradable sector, however, when facing sudden stops, countries were forced to readjust and reallocate their factors of production to the tradable sector in order to produce the tradable surplus necessary to reimburse foreign liabilities previously accumulated. As we see in Figure 3, relative prices decreased in the peripheral countries relatively more than in the rest of the EA11 over 2008-2013. These adjustments happened at a high social cost. In Spain and Greece, in particular, the readjustment resulted in a steep increase in unemployment. Wages fell by 16% in Greece, 5% in Ireland, remained stable in Portugal and slowed down in Spain between 2008 and 2013.

4. Determinants of the relative price of non-tradables

This section presents empirical evidence supporting the theoretical result that the real interest rate, together with the traditional BS effect, impact the evolution of non-tradable prices. To do so, it uses the data gathered on the evolution of non-tradable relative prices, apparent labor productivity in the tradable sector and real interest rates.¹³ All variables are expressed in deviations from the EA11 average. The choice of a reference here is neutral since all estimations are performed in logarithms.

The sample ranges from 1995 to 2013 and covers $N = 11$ EA countries, which amounts to $T = 19$ observations per country. In terms of size, the sample is close to previous studies of the BS effect, for instance [De Gregorio et al. \(1994\)](#) use data for 14 OECD countries over 1970-1985 (16 observations per country), or [Bénassy-Quéré and Coulibaly \(2014\)](#) use a dataset including 12 European countries over 1985-2006 (21 observations per country).

Figure 6 displays non-tradable prices, real interest rates and apparent labor productivity in the tradable sector, over 1995-2013, in core and periphery countries (weighted averages; the figures for each countries are presented in Appendix). The figures highlight both the BS effect and the real interest rate effects analyzed earlier: in the periphery for example, real interest rates declined by about 1.0% over 1995-2008 compared to the EA average, while non-tradable relative prices increase by 12.2% and productivity in the tradable sector increased (25.0%) compared to the EA average. In core countries, real interest rates increased by 0.3% over 1995-2008 relatively to the EA average, while non-tradable prices and tradable productivity decreased by 17.6% and 13.3% respectively, relatively to the EA average (numbers are also given in Table 6).

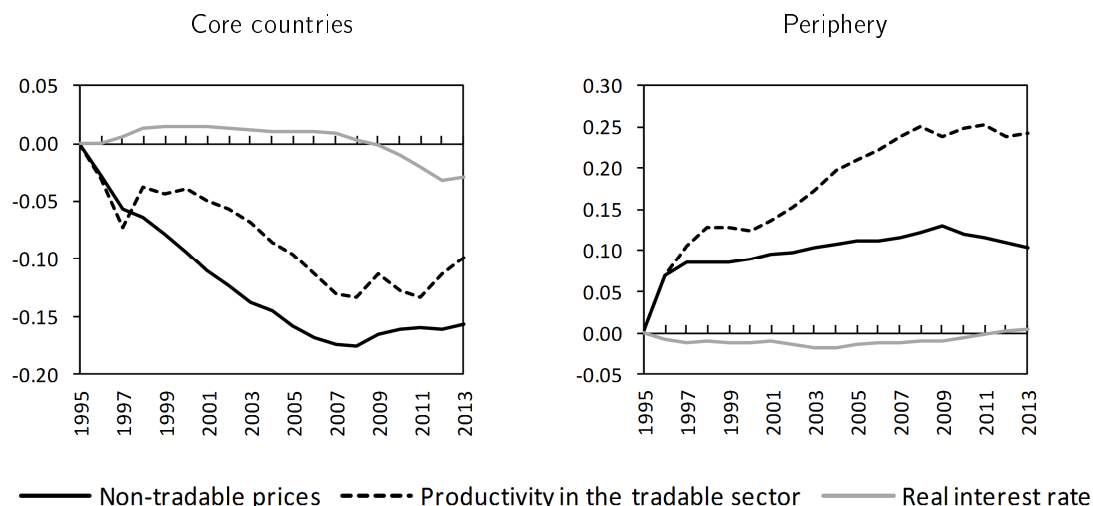
To deal with data limitations, panel techniques are used to estimate equation (6). With nonstationary series, equation (6) needs to be a cointegration relationship, as is usually the case in the BS framework. Therefore, before estimating equation (6), panel unit root tests and tests for the existence of a cointegration relationship are performed.¹⁴ The presence of structural breaks will be tested, as the sample covers both the adoption of the common currency and the 2010 euro crisis.

For robustness, all tests and estimations are performed using the 5% and 15% thresholds value for the measure of tradability. Estimates will also be provided for a sample covering the shorter

¹³A 2-year moving average (average of the value in t and $t - 1$) for the interest rate is used to capture the inertia of capital adjustment and its consecutive effect on the relative price.

¹⁴The tests are performed with GAUSS, using the codes provided by J. Westerlund, J.L. Carrion-i-Silvestre and N.C. Mark & D. Sul. OLS estimates for variables in first difference are performed using Stata.

Figure 6 – Non-tradable prices, productivity in the tradable sector and long-term real interest rate in core and periphery countries
1995-2013, log deviations from the EA11 average



Source: author's calculations using Eurostat, BACI and UN ServiceTrade and Ameco.

Note: non-tradable prices and productivity in the tradable sector are measured using the 10% threshold for tradability. The real interest rate is a 2-year moving average. Variables for each group are weighted averages (weight: gross value added at current prices).

period 1995-2009 to see if results are relevant when not taking into account the 2010 euro crisis. Finally, OLS estimates for variables in first difference will be presented for the four samples (the three using different thresholds and the one with the shorter time period).

4.1. Panel unit root and cointegration tests

The presence of unit roots in the series is studied using the third generation panel unit root test of [Bai and Carrion-i-Silvestre \(2009\)](#), allowing for heterogeneous panels with cross-section dependence and multiple structural breaks. The case for cross-section dependence is especially relevant here since real interest rate divergence resulted from nominal interest rate convergence in the euro area around the euro's inception. This test allows also the presence of multiple structural breaks, which number and dates are unknown and heterogeneous across countries. These shifts can affect both the level and the slope of each time series. Allowing for structural breaks is important in the analysis since the sample covers both the adoption of the common currency and the 2010 euro crisis.

This test has a null hypothesis of a unit root. More precisely, after identifying and taking into account the number and locations of structural breaks for each series (identified using the sequential procedure in [Bai and Perron, 1998](#)) and the common factors (estimated using the BIC criterion), this test pools modified Sargan-Bhargava (MSB) tests for individuals series. Three different pooling methods are used resulting in three different test statistics: Z , a standardization of individual statistics, and P and P_m combining their p -values. When shifts in trends are present, a simplified MSB test is also performed on individual series, adding three other pooled statistics: Z^* , P^* and P_m^* . Monte Carlo simulations confirm the good performance of the tests in finite samples (see [Bai](#)

and Carrion-i-Silvestre, 2009).

Up to two structural breaks are found for each country time series, and one on average for each of the 3 variables (relative price, productivity in the tradable sector and real interest rate).¹⁵ Results are presented in Table 1. It can be concluded that at conventional levels of significance, all series are non-stationary.

Cointegration tests are then performed. We use the third generation test proposed by Westerlund and Edgerton (2008), which allows for heterogeneous specifications in both the long and short run parts of the error correction model, based on the data. It also takes into account cross-section dependence and unknown structural breaks in both the mean and slope of the cointegrated regression. The authors suggest two simple tests for the null hypothesis of no cointegration derived from the Lagrange multiplier (LM) based unit root tests: the coefficient version (ϕ_N) and the t-test version (τ_N). Three different options are presented: the case with no break, the case with a shift in level only, and the case with a shift in level and trend. The tests generally perform well even in small samples.

Table 2 give the results of the tests: the two statistics reject the null hypothesis of no cointegration at the 10% level of significance in every case, except the τ_N statistic in the model with no shift.

4.2. Estimation of the long-run relationship

The long-run relationship is estimated using panel Dynamic OLS (DOLS) techniques. Two main approaches have been proposed in the literature that both deal with serial correlation and the endogeneity of the regressors: the full modified ordinary least squares (FMOLS) and the dynamic ordinary least squares (DOLS). The DOLS procedure consists in estimating a long-run relationship by instrumental variables using leads and lags of the differenced endogenous variables as instruments. Kao and Chiang (2001) show that DOLS outperform both OLS and FMOLS estimators in estimating cointegrated panel regressions. We use the extension to the DOLS framework suggested by Mark and Sul (2003), which allows for individual heterogeneity through different short-run dynamics, individual-specific fixed effects and individual-specific time trends.

The empirical model corresponding to equation (6) is:

$$\ln\left(\frac{p_{N,i,t}}{p_{N,EA,t}}\right) = \eta_i + \gamma_i t + \mu_t + \beta_1 \ln\left(\frac{A_{T,i,t}}{A_{T,EA,t}}\right) + \beta_2 \ln\left(\frac{1 + r_{i,t}}{1 + r_{EA,t}}\right) + \varepsilon_{i,t} \quad (7)$$

where η_i and $\gamma_i t$ are country-specific fixed effects and trends, μ_t is a common-time effect, and $\varepsilon_{i,t}$ is the idiosyncratic error.

Table 3 report the estimation for the single BS effect (columns 1 and 3), and of the BS and real interest rate effects (columns 2 and 4). For robustness, a first estimation is implemented with country-specific fixed effects and trends (columns 1 and 2), while the second also includes a common-time effect (columns 3 and 4).

It appears that both explanatory variables (tradable productivity and real interest rate, in deviations from the EA average) are significant at the 1% level and have the expected sign. A +1% differential in the tradable sector productivity raises the non-tradable price by 0.36% to 0.66% relative to the

¹⁵The break is most recurrent in 2010 for the relative price, 1998 for the productivity in the tradable sector and 2007 for the real interest rate.

Table 1 – Third generation panel unit root tests

	$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$	$\ln(\frac{1+r}{1+r_{EA}})$
Constant and trend (no break)			
Z	-1.370	-0.689	-0.367
P_m	0.247	0.749	-1.163
P	23.640	26.967	14.286
Trend shifts			
Z	0.758	0.157	0.058
P_m	-0.818	-0.002	-1.460
P	16.572	21.99	12.313
Z^*	2.152	0.996	0.051
P_m^*	-1.429	-0.028	-0.985
P^*	12.522	21.815	15.465

Note: the test has a null hypothesis of a unit root. Country-specific intercepts and trends are included (model 2). See [Bai and Carrion-i-Silvestre \(2009\)](#) for a description of the tests. The 1%, 5% and 10% critical values for the standard normal distributed Z and P_m statistics are 2.326, 1.645 and 1.282, while the critical values for the chi-squared distributed P statistic are 40.289, 33.924 and 30.813, respectively. The number of common factors are estimated using the panel Bayesian information criterion proposed by [Bai and Ng \(2002\)](#), and the test was estimated with a maximum number of breaks of 3.

Source: author's calculations.

Table 2 – Third generation panel cointegration test of [Westerlund and Edgerton \(2008\)](#)

	τ_N		ϕ_N	
	value	p -value	value	p -value
No shift	-1.373	0.085	-0.673	0.250
Level shift	-4.137	0.000	-2.422	0.008
Regime shift	-6.99	0.000	-4.358	0.000

Note: the test has the null hypothesis of no-cointegration. The breaks are determined by grid search at the minimum of the sum of squared residuals. The p -values are for one-sided test based on the normal distribution.

Source: author's calculations.

Table 3 – Panel cointegration estimates of the Balassa-Samuelson and real interest rate effects

Dependent variable : $\ln(\frac{p_N}{p_{N,EA}})$, 1995-2013				
	No common time effect (μ_t)		Common time effect (μ_t)	
	(1)	(2)	(3)	(4)
$\ln(\frac{A_T}{A_{T,EA}})$	0.611*** (0.126)	0.360*** (0.130)	0.659*** (0.132)	0.410*** (0.135)
$\ln(\frac{1+r}{1+r_{EA}})$		-1.287*** (0.360)		-1.186*** (0.376)

Note: standard errors, in parentheses, are based on Andrews and Monathan (1992) pre-whitening method. *, ** and *** denote significance at 10%, 5% and 1% levels respectively.

Source: author's calculations.

EA average. Introducing the real interest rate tends to depress the coefficient of the BS effect using the samples covering the 1995-2013 period.

A +1% differential in the real interest rate reduces the non-tradable price by 1.19% to 1.29% relative to the EA average. It thus seems that diverging evolution in the interest rate impacted greatly the evolution of non-tradable relative prices within the euro area over the period.

4.3. Robustness tests

For robustness, all tests and estimations are now performed using the 5% and 15% thresholds value for the measure of tradability. We first test for the presence of unit roots in the series using the third generation panel unit root test of Bai and Carrion-i-Silvestre (2009). Structural breaks are found again for every variable. There are up to two structural breaks for each time series, and one on average. Results for the tests are presented in Appendix (Table A.2). It can be concluded that at conventional levels of significance, all series are non-stationary.¹⁶

The stationarity of series in first difference are also tested, and it results that at conventional levels of significance, all series in first difference are stationary. The stationarity of variables in first difference is confirmed using the second-generation panel unit root test of Pesaran (2007). This test allows for cross-section dependence but does not allow the presence of structural breaks. Simulations made by Pesaran (2007) show that this cross-sectional augmented panel unit root test have satisfactory size and power even for relatively small samples ($T = N = 10$). Results of the panel unit root tests are presented also in Appendix (Table A.2). They confirm that, at conventional levels of significance, all series are stationary in first difference.

Cointegration tests are then performed for series that are non-stationary using test proposed by Westerlund and Edgerton (2008). Three different options are presented: the case with no break, the case with a shift in level only, and the case with a shift in level and trend. Table A.3 in the Appendix gives the results of the tests: the two statistics reject the null hypothesis of no

¹⁶Only the Z statistic for the tests driven for non-tradable prices present mixed results.

Table 4 – Panel cointegration estimates of the Balassa-Samuelson and real interest rate effects

Dependent variable : $\ln(\frac{p_N}{p_{N,EA}})$				
	No common time effect (μ_t)		Common time effect (μ_t)	
	(1)	(2)	(3)	(4)
5% threshold				
$\ln(\frac{A_T}{A_{T,EA}})$	0.650*** (0.125)	0.404*** (0.106)	0.722*** (0.137)	0.458*** (0.113)
$\ln(\frac{1+r}{1+r_{EA}})$		-1.181*** (0.353)		-0.994*** (0.360)
15% threshold				
$\ln(\frac{A_T}{A_{T,EA}})$	0.550*** (0.179)	0.406*** (0.130)	0.605*** (0.195)	0.461*** (0.138)
$\ln(\frac{1+r}{1+r_{EA}})$		-1.260*** (0.357)		-1.135*** (0.373)
10% threshold, 1995-2009				
$\ln(\frac{A_T}{A_{T,EA}})$	0.127 (0.162)	0.259*** (0.054)	0.147 (0.189)	0.284*** (0.054)
$\ln(\frac{1+r}{1+r_{EA}})$		-1.521*** (0.282)		-1.494*** (0.271)

Note: standard errors, in parentheses, are based on Andrews and Monathan (1992) pre-whitening method. *, ** and *** denote significance at 10%, 5% and 1% levels respectively.

Source: author's calculations.

cointegration at the 10% level of significance in every case, except the τ_N statistic in the model with a regime shift for the 5% threshold, and with no shift for the 15% threshold.

As all three series, measured using different thresholds (5% and 15%), are non-stationary and cointegrated, panel DOLS estimations of equation are performed to estimate equation (6). Table 4 reports the estimation for the single BS effect (columns 1 and 3), and of the BS and real interest rate effects (columns 2 and 4). For robustness, a first estimation is implemented with country-specific fixed effects and trends (columns 1 and 2), while the second also includes a common-time effect (columns 3 and 4). Estimates are also provided for a sample covering the shorter period 1995-2009 to see if results are relevant when not taking into account the 2010 euro crisis.

It appears that both explanatory variables (tradable productivity and real interest rate, in deviations from the EA average) are significant at the 1% level and have the expected sign using the two samples with different thresholds for the measure of tradability (5% and 15%). In the sample covering a shorter time period, tradable productivity is not significant when introduced alone. We can see that the impact of a +1% differential in the tradable sector productivity raises the non-

tradable price by 0.26% to 0.72% relative to the EA average. Introducing the real interest rate tends to depress the coefficient of the BS effect using the samples covering the 1995-2013 period, but increase the coefficient using the sample covering the 1995-2009 period. A +1% real interest rate differential reduces the non-tradable price by 0.99% to 1.52% relative to the EA average.

Finally, OLS estimates for variables in first difference are presented in table 5 for the four samples (the three using different thresholds and the one with the shorter time period). The two variables are significant at the 1% level using all four samples. The impact of a 1% increase in the tradable productivity ranges from a 0.17% to a 0.22% increase in non-tradable inflation. A 1% real interest rate growth ranges from a 0.91% to 2.03% decrease in non-tradable inflation.

Overall, the impact of a +1% differential in the real interest rate reduces the non-tradable price by 0.99% to 1.52% relative to the EA. It thus seems that diverging evolution in the interest rate impacted greatly the evolution of non-tradable relative prices within the euro area over the period. In periphery countries, over 1995-2008, changes in the interest rate could explain up to 13% of the changes in relative prices. In Greece, the fall in the real interest rate over 1995-2008 could explain almost half of the non-tradable price increase relative to the EA average, while in Germany the increase in the real interest rate might have contributed up to 7% of the decrease of the non-tradable price relative to the average of the EA (Table 6).

Table 5 – OLS estimates of the Balassa-Samuelson and real interest rate effects, first difference

Dependent variable : $\Delta \ln(\frac{P_N}{P_{N,EA}})$				
	No common time effect (μ_t)		Common time effect (μ_t)	
	(1)	(2)	(3)	(4)
10% threshold				
$\Delta \ln(\frac{A_T}{A_{T,EA}})$	0.185*** (-0.035)	0.172*** (-0.031)	0.185*** (-0.037)	0.172*** (-0.033)
$\Delta \ln(\frac{1+r}{1+r_{EA}})$		-0.962*** (-0.142)		-0.962*** (-0.149)
5% threshold				
$\Delta \ln(\frac{A_T}{A_{T,EA}})$	0.216*** (-0.039)	0.206*** (-0.035)	0.216*** (-0.041)	0.206*** (-0.037)
$\Delta \ln(\frac{1+r}{1+r_{EA}})$		-1.008*** (-0.152)		-1.008*** (-0.159)
15% threshold				
$\Delta \ln(\frac{A_T}{A_{T,EA}})$	0.187*** (-0.035)	0.168*** (-0.032)	0.187*** (-0.037)	0.169*** (-0.034)
$\Delta \ln(\frac{1+r}{1+r_{EA}})$		-0.911*** (-0.143)		-0.911*** (-0.150)
10% threshold, 1995-2009				
$\Delta \ln(\frac{A_T}{A_{T,EA}})$	0.174*** (-0.042)	0.192*** (-0.034)	0.174*** (-0.044)	0.193*** (-0.036)
$\Delta \ln(\frac{1+r}{1+r_{EA}})$		-2.032*** (-0.243)		-2.032*** (-0.255)

Note: country-specific time trends are not included.

Source: author's calculations.

Table 6 – Contributions of the Balassa Samuelson (BS) and the real interest rate effects to the non-tradable price growth
1995-2008, deviations from the EA average

	Growth			Contributions to non-tradable price growth	
	Non-tradable prices	Productivity in the tradable sector	Real interest rates	BS effect	Real interest rate effect
AT	-20.2%	-15.3%	0.4%	-4.0%	-0.6%
BE	-12.4%	-7.3%	-0.4%	-1.9%	0.6%
DE	-30.9%	-21.9%	1.4%	-5.7%	-2.1%
EL	7.6%	9.3%	-2.3%	2.4%	3.5%
ES	7.6%	31.5%	-1.0%	8.1%	1.5%
FI	-0.4%	-21.0%	0.3%	-5.4%	-0.5%
FR	-6.0%	-4.7%	-1.1%	-1.2%	1.7%
IE	31.7%	-23.6%	3.4%	-6.1%	-5.2%
IT	14.1%	27.4%	-1.4%	7.1%	2.1%
NL	-7.3%	0.9%	0.6%	0.2%	-0.9%
PT	9.2%	22.0%	0.0%	5.7%	0.0%
Core*	-17.6%	-13.3%	0.3%	-3.4%	-0.5%
Periphery*	12.2%	25.0%	-1.0%	6.5%	1.6%

*weighted averages, weight: gross value added at current prices.

Source: author's calculations.

Note: contributions are measured using the coefficients resulting from panel DOLS estimates with no common time effect on the sample covering the 1995-2009 periods and using the 10% threshold for the measure of tradability, see Table 4, 3rd estimate, column (2). For example, in Greece (EL), the real interest rate contribution to the non-tradable price increase is: $(-2.3) \times (-1.521) = 3.5\%$. Therefore, the real interest rate fall in Greece could explain $3.5/7.6 = 46\%$ of the non-tradable price increase over 1995-2008 relative to the EA11.

5. Concluding Remarks

This paper has analyzed how the real interest rate influences the dynamics of non-tradable relative prices. The theoretical framework, incorporating two factors of production in the traditional Balassa-Samuelson model, shows that the real interest rate fall in the euro area periphery following the single currency's inception induced an increase in the relative price of non-tradable goods. The paper then documents the dynamics of the tradable to the non-tradable sector over 1995-2013 using a new dataset and carries out an econometric estimation for 11 EA countries to quantify the contribution of the pure Balassa-Samuelson effect and the impact of the interest rate on non-tradable relative prices.

The results confirm that, together with the traditional BS effect, diverging evolutions in real interest rates seem to have contributed to the evolution of non-tradable relative prices within the euro area over the period. In Greece, the fall in the real interest rate over 1995-2008 could explain almost half of the non-tradable price increase relative to the EA average, while in Germany the increase in the real interest rate might have contributed up to 7% of the decrease of the non-tradable price relative to the average of the EA.

This result is especially important in the context of the debate on the relative price adjustment and the subsequent surveillance within Europe. Divergence across euro area members challenges greatly the efficiency of a single monetary policy. This divergence was translated, before the crisis, in strong inflation differentials as we have seen. While the introduction of the euro should have fostered a real convergence as capital flew towards so-called "catching-up" economies, these capital flows were indeed mainly allocated in the less innovative non-tradable sectors and fueled strong price increases. Since the 2008 financial crisis, in the EA periphery, increased interest rates may have contributed to internal rebalancing but labor reallocation happens at a high social cost as the non-tradable sector is more labor-intensive than the tradable sector. The divergence thus now takes the form of strong heterogeneities in how economies reacted to the financial crisis, and through high differentials in unemployment rates across countries.

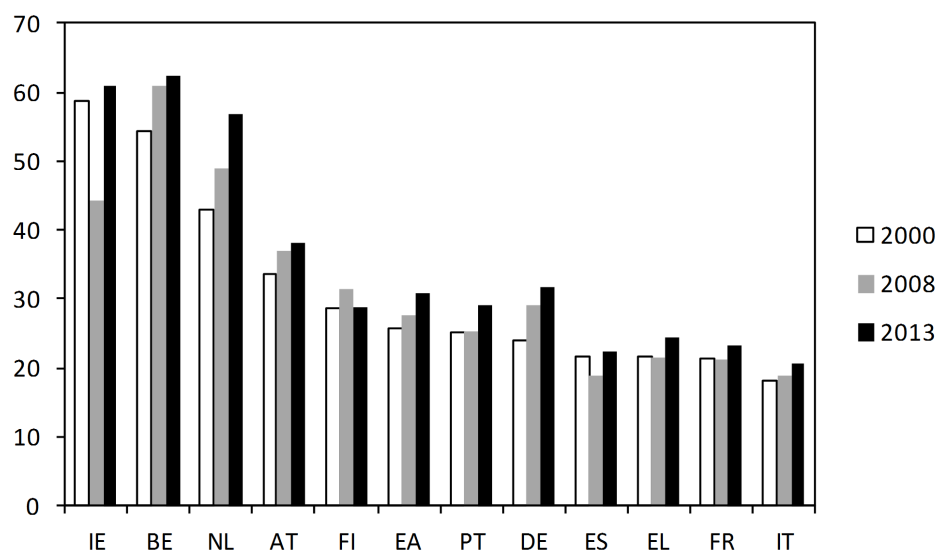
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Appendix

Figure A.1 – Openness ratio by country
2000, 2008 and 2013, in %



Source: author's calculations using Eurostat, BACI and UN ServiceTrade.

Note: the openness ratio is the ratio of total trade (imports+exports) to total production.

Table A.1 – Openness ratio by sector, EA11
2000 and 2000-2013 average in %, 2013/2000 growth in p.p.

Sector		2000 (%)	growth (%) 2013-2000	average (p.p.) 2000-2013
B	Mining and quarrying	184.1	179.0	249.4
C	Manufacturing	44.0	10.1	48.4
I	Accommodation and food service activities	9.4	17.4	23.7
H	Transportation and storage	26.1	-4.1	22.8
A	Agriculture, forestry and fishing	19.0	8.2	22.8
J	Information and communication	12.5	10.3	15.8
N	Administrative and support service activities	11.0	6.3	13.7
M	Professional, scientific and technical activities	9.0	3.7	9.0
K	Financial and insurance activities	6.8	2.2	7.8
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	3.0	0.4	3.1
D	Electricity, gas, steam and air conditioning supply	1.5	1.9	3.0
F	Construction	1.9	0.0	1.7
R	Arts, entertainment and recreation	2.1	-0.5	1.5
O	Public administration and defence; compulsory social security	1.9	-0.8	1.4
S	Other service activities	0.5	1.1	0.9
P	Education	0.3	0.5	0.7
E	Water supply; sewerage, waste management and remediation activities	0.0	0.2	0.2
Q	Human health and social work activities	0.0	0.1	0.2
L	Real estate activities	0.0	0.0	0.0
TOTAL		33.1	6.3	34.8

Source: author's calculations using Eurostat, BACI and UN ServiceTrade.

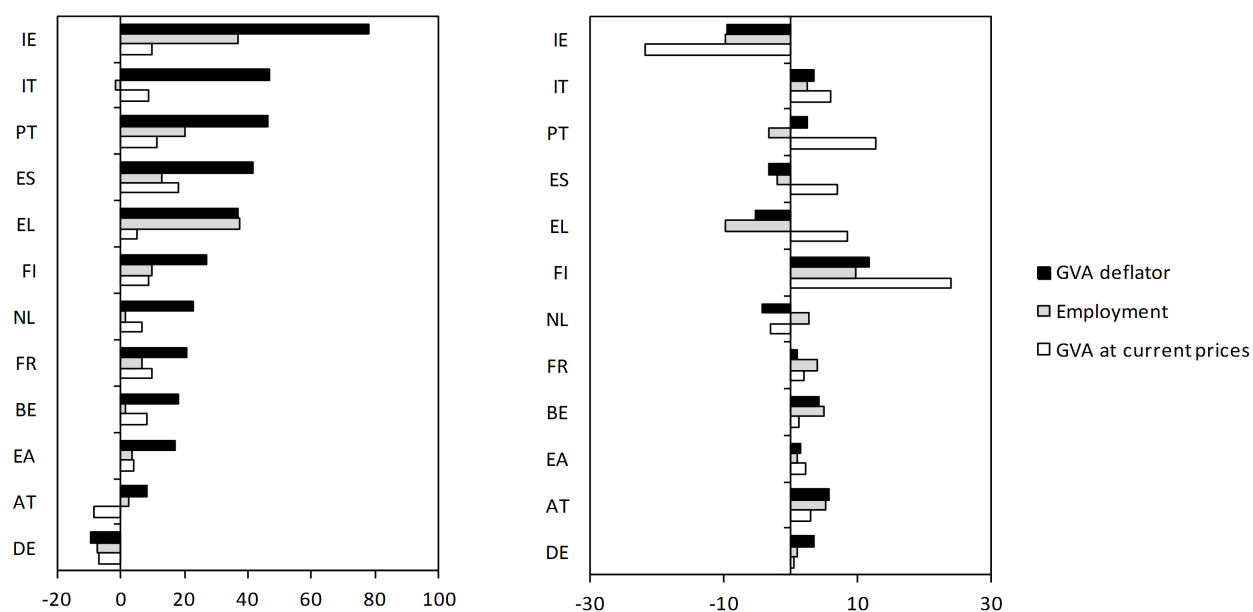
Note: the red lines indicate the 15%, 10% and 5% thresholds. The openness ratio is the ratio of total trade (imports+exports) to total production.

Figure A.2 – Evolution of the non-tradable relative to the tradable sector

5% threshold for the measurement of tradability.

(a) 2008/1995

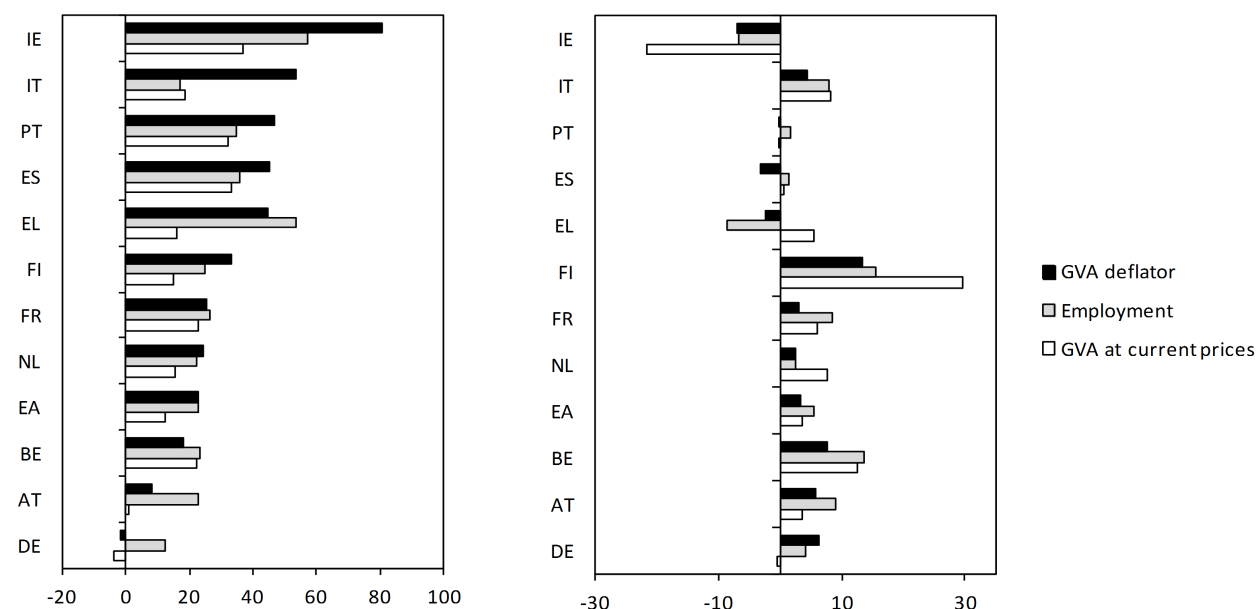
(b) 2013/2008



15% threshold for the measurement of tradability.

(c) 2008/1995

(d) 2013/2008

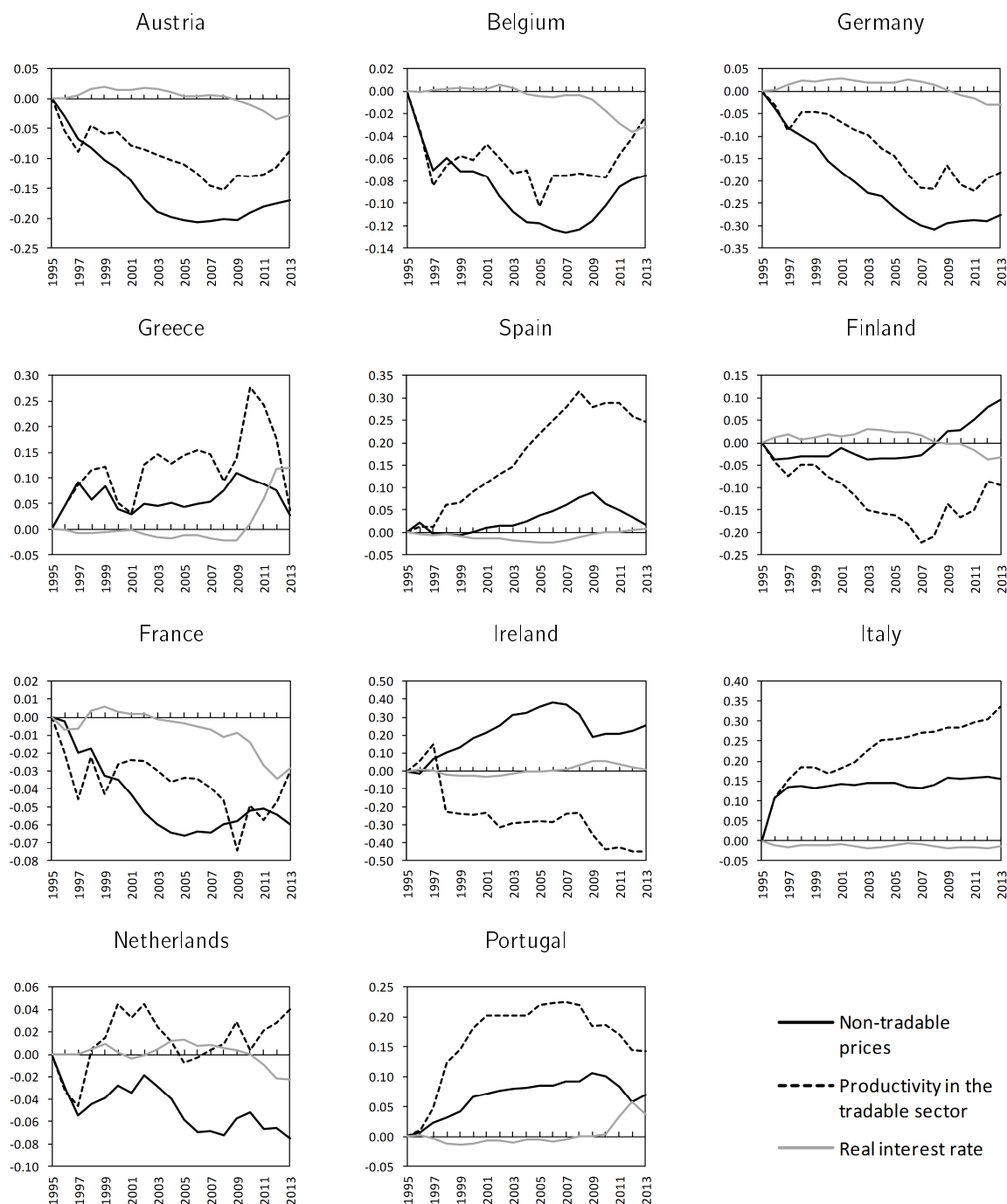


Source: author's calculations using Eurostat, BACI and UN ServiceTrade.

Note: relative prices are the ratio of non-tradable prices relative to the tradable price of the EA11.

Employment is measured in thousands of hours worked.

Figure A.3 – Non-tradable prices, productivity in the tradable sector and long-term real interest rate 1995-2013, log deviations from the EA11 average



Source: author's calculations using Eurostat, BACI and UN ServiceTrade and Ameco.

Note: non-tradable prices and productivity in the tradable sector are measured using the 10% threshold for tradability. The real interest rate is a 2-year moving average.

Table A.2 – Second and third generation panel unit root tests

(a) Third generation panel unit root tests for variables in level

	5% threshold		15% threshold	
	$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$	$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$
Constant and trend (no break)				
<i>Z</i>	-1.463	-0.008	-1.191	-1.177
<i>P_m</i>	2.154	-0.867	-0.112	0.951
<i>P</i>	36.285	16.251	21.257	28.310
Trend shifts				
<i>Z</i>	3.094	1.349	0.587	0.458
<i>P_m</i>	-1.564	-2.016	-0.075	-0.985
<i>P</i>	11.628	8.63	21.504	15.465
<i>Z*</i>	9.523	1.986	4.424	3.096
<i>P_m*</i>	-1.758	-1.817	-0.538	-1.478
<i>P*</i>	10.336	9.951	18.432	12.596

Note: test statistics in italic reject the null hypothesis of a unit root.

(b) Second and third generation panel unit root tests for variables in first difference

Third generation panel unit root tests of [Bai and Carrion-i-Silvestre \(2009\)](#)

	$\ln(\frac{1+r}{1+r_{EA}})$	10% threshold		5% threshold		15% threshold	
		$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$	$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$	$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$
<i>Z</i>	-2.682	-2.845	-3.030	-2.889	-3.067	-2.831	-3.050
<i>P_m</i>	6.690	9.170	13.587	10.075	13.825	8.842	13.975
<i>P</i>	66.379	82.826	112.124	88.829	113.707	80.648	114.699

Second generation panel unit root tests of [Pesaran \(2007\)](#)

	$\ln(\frac{1+r}{1+r_{EA}})$	10% threshold		5% threshold		15% threshold	
		$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$	$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$	$\ln(\frac{p_N}{p_{N,EA}})$	$\ln(\frac{A_T}{A_{T,EA}})$
value	-4.203	-3.101	-3.71	-5.193	-3.175	-3.382	-3.517
<i>p-value</i>	0.000	0.001	0.000	0.000	0.001	0.000	0.000

Note: the tests have the null hypothesis of a unit root. For variables in level, country-specific intercepts and trends are included, for variables in first difference only country-specific intercepts are included. For the tests from [Bai and Carrion-i-Silvestre \(2009\)](#), the 1%, 5% and 10% critical values for the standard normal distributed *Z* and *P_m* statistics are 2.326, 1.645 and 1.282, while the critical values for the chi-squared distributed *P* statistic are 40.289, 33.924 and 30.813, respectively. The number of common factors are estimated using the panel Bayesian information criterion proposed by [Bai and Ng \(2002\)](#), and the test was estimated with a maximum number of breaks of 3.

Source: author's calculations.

Table A.3 – Third generation panel cointegration test of Westerlund and Edgerton (2008)

	τ_N		ϕ_N	
	value	<i>p-value</i>	value	<i>p-value</i>
5% threshold				
No shift	-2.006	0.022	-2.008	0.022
Level shift	-4.46	0.000	-4.673	0.000
Regime shift	-2.156	0.016	-0.093	0.463
10% threshold, 1995-2009				
No shift	-1.295	0.098	-0.670	0.252
Level shift	-3.045	0.001	-2.318	0.010
Regime shift	-5.227	0.000	-2.603	0.000

Note: the test has the null hypothesis of no-cointegration. The breaks are determined by grid search at the minimum of the sum of squared residuals. The *p-values* are for one-sided test based on the normal distribution.

Source: author's calculations.